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(12) **United States Patent**  
**Yamazaki et al.**

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(54) **METHOD FOR REMOVING HYDROGEN FROM OXIDE SEMICONDUCTOR LAYER HAVING INSULATING LAYER CONTAINING HALOGEN ELEMENT FORMED THEREOVER**

(58) **Field of Classification Search**  
CPC ..... H01L 21/02131; H01L 21/02565; H01L 21/31629; H01L 27/1214; H01L 27/1225;  
(Continued)

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(57) **ABSTRACT**

An object is to provide a semiconductor device with stable electric characteristics in which an oxide semiconductor is used. An impurity such as hydrogen or moisture (e.g., a hydrogen atom or a compound containing a hydrogen atom such as H<sub>2</sub>O) is eliminated from an oxide semiconductor layer with use of a halogen element typified by fluorine or chlorine, so that the impurity concentration in the oxide semiconductor layer is reduced. A gate insulating layer and/or an insulating layer provided in contact with the oxide semiconductor layer can be formed to contain a halogen element. In addition, a halogen element may be attached to the oxide semiconductor layer through plasma treatment under an atmosphere of a gas containing a halogen element.

(51) **Int. Cl.**  
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**20 Claims, 30 Drawing Sheets**

